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RESEARCH NOTES

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No. 1-53
September 14. 1953

Soil Conditioners

Soil Conditioners Vary Widely in Federal-State Tests - (USDA, Agricultural Research Administration release - USDA - 2526-52, November 21, 1952.)

Preliminary screening tests show a wide range of effectiveness in 28 products marketed as soil conditioners, the U.S.Department of Agriculture said today.

In a round-up of recent information from Federal-State studies, Dr. R. Q. Parks, who is head of the Division of Soil Management and Irrigation Agriculture, Bureau of Plant Industry, Soils, and Agricultural Engineering, reports:

Short-term evaluation tests confirm preliminary findings that the best of the conditioners are highly effective agents in stabilizing whatever structure of soil has been prepared. They hold unusual promise in certain soils for preventing soil crusting and for erosion control. In studies at the U. S. Salinity Laboratory at Riverside, Calif., some of the compounds have shown a marked influence in improving both non-saline-alkali and saline-alkali soils under irrigation. Dr. Parks underscores the point that the usefulness of the new compounds is in stabilizing whatever soil structure is prepared. For best results they should be applied to a well-prepared seedbed. The soil should then be thoroughly mixed, and stirred again after a rain or an irrigation. Spraying a solution of soil conditioner on a heavy baked clay without cultivation cannot be expected to improve soil structure.

Active ingredients in the materials tested fall into five groups of chemical compounds: Polyvinylites, polyacrylites, cellulose derivatives, lignin derivatives and silicates. Although preliminary ratings indicate considerable differences in the effectiveness of the compounds, definite ratings cannot be made until these are tested on more soils, under many diverse conditions, and over a greater period of time. The screening tests with a number of materials reveal a wide range--from 15 to 98 percent--in the amount of active ingredient used in the different commercial compounds. There is considerable variation in the cost of materials needed to treat 100 square feet of the plow layer of soil--from 50 cents to $7.90. Per acre costs would range from $200 to $3,000 at rates recommended by the manufacturers for the various compounds.

In exploring ways to use the more effective compounds in agriculture, the scientists note that seed germination and rooting have been enhanced in certain soil when the compounds were mixed with the soil to a depth of 4 to 6 inches. One of the big problems for research is to determine the best tillage equipment for this job. Tracer tests in which radioactive phosphorus was combined with conditioners have indicated that the disk and harrow do not distribute the material evenly throughout the plow depth. In experimental cotton rows, treatment of a soil band only 4 inches wide permitted maximum benefits in the immediate area of the plants and required only 1/10th of the material that would have been needed to treat the entire row. Preliminary tests indicate that a shallow application to the top 1/2 to 1 inch of soil will be sufficient to prevent crusting on soils where the seed of small-seeded grasses and legumes are broadcast.

Dr. Parks says users should keep in mind that the compounds are not fertilizers. They will not permanently affect the nutrient supplying capacity of the soil. The findings show they cannot increase the water-holding capacity of most agricultural soils. Among many questions still to be answered are how long the compounds will persist in the soil and how soon the soil would need another treatment. Early experiments indicate that products in which the polyacrylates are the active ingredient are quite resistant to bacterial attack.

Report of Tests on Soil Conditioners - (Research Report No. 256, BPISAE, USDA, C. S. Slater and G. B. Posey)*

Tests on soil conditioners were carried on in 16 states and Hawaii. Reports from 24 locations were summarized by a committee on soil conditioners composed of Bureau of Plant Industry, Soils and Agricultural Engineering and Soil Conservation Service workers.

Materials Tested

Most of the materials tested are Krilium formulations furnished by the Monsanto Chemical Company as follows:

K 6 (CRD 186)	Calcium salt of Vinyl acetate maleic acid. Contains approximately 6% calcium cation. It is considered 100% active.
K 9 (CRD 189)	Sodium salt of hydrolysed polyacrylonitrile. Contains approximately 18% sodium cation. It is considered 100% active.
K 631	A 25% formulation of K 6. 75% inert material.
K 931	A 25% formulation of K 9. 75% inert material.
K 991	A 10% formulation of K 9. 90% inert material.

*Detailed report is available in Regional Research Liaison Representative's office.

Other materials were tested on a much less extensive basis. They included Ultra-wet, Flotal and CMC. Ultra-wet is related to the general family of wetting agents. Flotal is a soil amendment originating in Italy, based on iron salts and some organic material. CMC is carboxymethyl cellulose.

Discussion of Materials and Results

Ultra-wet: Limited studies at three locations (Californis, Iowa, Maryland) with this material failed to show any substantial benefits on crops or soils.

Flotal: Limited studies at two locations (Idaho, Maryland) with this material indicated that it had an effect in improving permeability. Its acid reaction and chemical composition indicates that it is not adapted to humid region soils. There is a possibility that it may be more effective than gypsum and sulphur in conditioning alkaline and saline soils.

CMC: CMC was tested at only one location (Oregon) and on the basis of reported data, it appears as effective as Krilium in improving percolation. However, the experimenter concluded that the Krilium compounds were generally the more promising.

Krilium: (1) The reports on applications of Krilium generally indicate that where these materials were mixed well with soil in suitable proportions, structurally poor soils were improved. Favorable crop responses were evidenced in several cases.

(2) Under some conditions Krilium tended to seal the soil and cause increased runoff when first applied. This was especially so with applications that remained on or near the surface. Adverse effects usually disappeared after a time. Infiltration rates and stability against erosion then became greater for the treated soil than for the untreated state.

(3) A number of application difficulties were experienced with Krilium. These included (a) clogging and gumming-up of spreading equipment due to hygroscopic nature and finely powdered condition of the material, (b) when applied on the soil surface the fine Krilium dust was readily blown away; also, it was washed away by flash rains under hazardous erosion conditions, (c) on moist soil heavy surface applications tended to "gum-up" before the material could be sufficiently worked into the soil and "gum balls" were left sometimes after working.

(4) It is evident from the reports that application methods would need further study before it could be determined how the material might be satisfactorily incorporated with the soil. Disking, following surface application of the conditioner, is the method most generally used in the tests. However, Alexander and Hulbert, at the American Society of Agricultural Engineers' Chicago meeting in December, 1952, reported that disking was only partly effective as mixing equipment.

(5) In one test at Nebraska, conducted by F. L. Duley, Krilium (K 9) at rates of 1000, 2000, and 4000 pounds per acre was less effective in reducing soil loss and runoff than a $2\frac{1}{2}$ ton per acre straw mulch. Following are the results from the period from May 19 to November 16, 1952:

	Amt. of Rain	Krilium - Lbs. per acre				Straw $2\frac{1}{2}$ tons per acre
		0	1000	2000	4000	
Soil loss - lbs.per acre	9.32	35611	20136	4023	3243	176
Run-off - Inches	9.32	3.09	3.09	2.48	2.26	0.26

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RESEARCH NOTES

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No. 2-53

September 22, 1953

Soil Testing - Available Phosphorus

Estimation of Available Phosphorus in Soils by Extraction with Sodium Bicarbonate - BPISAE, Agricultural Research Administration, Research Report No. 260, Olsen, Sterling R.; Cole, C. V.; Watanabe, Frank; and Dean, L. A.

(The above manuscript is made available at this time to collaborators, cooperators, and to others in soil testing laboratories in the various states. This report, with some revision, will be published as a U.S.D.A. Circular and any literature citation of the report should be as follows: U.S.D.A. Circular (In Press). The following summary is presented for your information.)

A new method for extracting soil phosphorus with sodium bicarbonate solutions is described along with relationship of the extractable phosphorus to plant available phosphorus and yield of dry matter.

A useful chemical extractant for plant available phosphorus in soils will (a) measure all or a definite proportion of the various forms of phosphorus in the same relative amounts as they are absorbed by plants, (b) correlate to a high degree with plant uptake of phosphorus and yield response to added phosphorus over a wide range of soil types, (c) minimize the secondary precipitation and adsorption reactions which may occur during the extraction, and (d) be adaptable to rapid, routine-test procedures.

Some of the currently used soil tests for phosphorus satisfy requirements (c) and (d), but fall short in varying degrees for (a) and (b). The chief incentive to develop a better test is the failure of a given method to apply to a wide variety of soils.

Method of Extraction

The following method is recommended, in principle, for extracting soils with $NaHCO_3$ solutions:

Prepare a 0.5 molar $NaHCO_3$ solution adjusted to pH 8.5 with NaOH.

Shake 5 grams of soil with 100 ml. of the $NaHCO_3$ solution and one teaspoon of carbon black (Darco G-60 or other suitable carbon black) for 30 minutes. The rate of shaking should be constant. Add more carbon black to the flask after shaking if filtrate is not clear.

Filter through Whatman No. 40 or other suitable paper.

Add 5 ml. of the filtrate to a 25 ml. volumetric flask and determine phosphorus by the Dickman and Bray method. The molybdate reagent is modified by adding an extra 50 ml. of concentrated HCl per liter to neutralize the $NaHCO_3$ in a 5 ml. aliquot.

A few precautions to be observed may be helpful. If the flask containing the aliquot is shaken too vigorously after the addition of the molybdate reagent. some solution may be lost due to the rapid evolution of CO_2. After CO_2 evolution has subsided, wash down the neck of the flask and dilute to about a 20 ml. volume. Add one ml. of the dilute $SnCl_2$ solution, shake immediately and dilute to volume. Failure to observe this precaution with respect to the $SnCl_2$ will give erratic results.

On some soils high in extractable phosphorus it may be necessary to take less than a 5 ml. aliquot. If so, the total volume should be made up equivalent to 5 ml. of the $NaHCO_3$ solution in order to maintain the proper acidity for developing the color. The standard curve should be prepared with the $NaHCO_3$ included.

The carbon black (Darco G-60) releases phosphorus when treated with $NaHCO_3$. Therefore, the carbon black is pre-treated with the $NaHCO_3$ solution by leaching, washing with water, and drying.

Summary

The results and their implications are summarized below:

1. A new method for extracting soil phosphorus with 0.5 molar solutions of sodium bicarbonate at pH 8.5 is described. The method is adaptable to rapid, routine, soil testing procedures.

2. The effect of concentration of $NaHCO_3$, soil to solution ratio, time of shaking and pH of the extracting solution on the amount of phosphorus dissolved is discussed.

3. The amount of phosphorus extracted with $NaHCO_3$ shows higher correlations with a measure of plant available phosphorus, or 'A' value, than the Bray, water-soluble and CO_2-soluble methods on a group of both acid and calcareous soils.

4. Secondary precipitation and adsorption reactions which are known to occur in soils during the extraction process with mineral acids are greatly minimized in the $NaHCO_3$ extraction.

5. The $NaHCO_3$ - soluble phosphorus was less than 75 pounds P_2O_5 per acre on 90 percent of a total of 77 soils, on which German millet gave a significant yield response to phosphate, and less than 50 on 75 percent of the total.

6. Based on the evidence reported here, a yield response to applied phosphate may be expected, provided other growth factors besides phosphorus are not limiting, in relation to level of $NaHCO_3$ - soluble phosphorus in pounds of P_2O_5 per acre as follows: below 50, a response; 50 to 75, a probable response; 75 to 100, a possible response; over 100, a response unlikely. These figures are meant to indicate only a general relationship between crop response and level of extractable phosphorus. Crop requirements for phosphorus and root-zone feeding areas must be considered also. For example, the values are probably too low for potatoes and too high for corn.

7. The form of phosphorus extracted by $NaHCO_3$ appears to be largely the exchangeable phosphorus, or the phosphorus on the surface of soil particles readily exchanging with P^{32} in the same ionic form.

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RESEARCH NOTES

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No. 3-53

September 22, 1953

Fertilizers - Potatoes

Fertilization of Potatoes in Maine - Struchtemeyer, Roland A. - Proceedings Sixth Annual Meeting of Collaborators with Soil and Fertilizer Laboratory, BPI&SAE, ARA, USDA, Beltsville, Md., March 2-4, 1953.

(This paper was presented at the above meeting and is here reproduced to point up problems that may be connected with high rates of fertilizer usage, and to stimulate observations of similar results as they might apply to other crops. This material is for administrative use only.)

Introduction

In Maine most of the soils now planted to potatoes are true podsols, and the natural fertility of such soil has been found to be quite low. Analysis of soil samples taken from timbered areas, presumably virgin soils, showed a readily soluble P_2O_5 content of 44 pounds per acre and an exchangeable K_2O content of 76 pounds per acre. Therefore, it is quite apparent that if high yields are going to be produced on such soils, the farmers need to add large amounts of plant nutrients.

Through experience farmers have acquired this information and so potato growers in Maine have long been using large amounts of commercial fertilizers. They have been investing better than $10,000,000 annually in fertilizers, and much of this has been applied to the soil with no regards for the actual fertility level of the fields.

Recent surveys show that farmers have been applying, on the average, approximately a ton of 6-9-12 fertilizer per acre. Since this is an average figure it means that many farmers have been using more than this amount. The farmers are actually applying 120 to 160 pounds of nitrogen (N), 180 to 320 pounds of phosphoric acid (P_2O_5) and 240 to 320 pounds of potash per acre. Analysis of the potato plant shows that a 600 bushel (200 barrel) crop will take from the soil about 120 pounds of N, 30 pounds of P_2O_5 and 200 pounds of K_2O. Comparing the figures for the plant nutrients added in the form of fertilizer and those removed in the tubers, it becomes apparent that past practices should provide for a tremendous build-up of phosphorus in the soil and for some build-up of potassium.

Soil samples taken from experimental plots where the amount of fertilizer applied per acre is available for a number of years show that there has been a build-up in the amount of P_2O_5 and K_2O in the soil. This build-up is directly related to the number of times that potatoes have appeared on the land.

Procedure

Numerous fertilizer trials have been established at various locations over the state. At these various locations the effect of varying amounts of fertilizer and varying ratios of fertilizer nutrients were considered.

In the case of nitrogen the rates of application varied from 0 to 180 pounds per acre. For phosphorus the rates of application varied from 0 to 240 pounds per acre and for potash from 0 to 320 pounds per acre.

Results

The results for the application of varying rates of nitrogen show that prior to 1946 the maximum yield response was usually obtained with 80 to 120 pounds of nitrogen per acre. Since 1946 the use of improved insect and disease control methods has meant that the vine remains green longer and consequently, response has been noted for nitrogen additions of 150 pounds and occasionally 180 pounds per acre. It might be of interest to note here that the same general scheme of response was also obtained for irrigated potatoes.

The results also showed that the greatest yield response was obtained from the first 40 to 80 pound increment of nitrogen in this fertilizer. From these trials it was also apparent that potatoes following a good legume green manure crop could get along on about 20 pounds less nitrogen per acre.

The amount of readily available potash in the soil has a very decided influence on the response obtained by K_2O applied as a fertilizer. Soils low in available potash will occasionally show yield responses to applications of K_2O as high as 240 to 280 pounds per acre. However, soil medium to high in exchangeable potash seldom shows a yield response to more than 100 to 120 pounds of K_2O. Seventy-two percent of soils tested in Maine contained medium or high potash.

As has been previously mentioned, a 600 bushel crop of potatoes removes from the soil only about 30 pounds of P_2O_5. Still very few, if any, farmers in the past have applied less than 180 or 200 pounds of P_2O_5 per acre every time potatoes appear on that land. This 30 pounds to 180 or 200 pounds relationship should make one wonder about the efficiency of the phosphorus fertilization program.

Maine has been working for 20 years on this phosphorus problem and has just recently summarized this work in the Maine Agricultural Experiment Station Bulletin 506.

A summary of the data shows that maximum response was received from the first 40 to 80 pounds of P_2O_5 applied. Soils high in readily soluble phosphate show no response to applications of P_2O_5 in excess of 100 pounds per acre. Soils low in readily soluble P_2O_5 will respond to applications as high as 240 pounds of P_2O_5 per acre.

Summary

Farmers growing potatoes should have their fields tested for P_2O_5 and K_2O so that they might more efficiently utilize their fertilizer.

Through excessive fertilization in the past, sizeable amounts of P_2O_5 and K_2O have accumulated in the soil.

The amount of P_2O_5 and K_2O in the soil very definitely determines the amount of crop response that can be expected from the application of these materials.

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No. 4-53

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ORCHARD SOIL MANAGEMENT - SOD VS. CLEAN CULTIVATION

Moisture in Orchard Soils as Influenced by Age of Sod and Clean Cultivation, Kenworthy, A.L.; Quarterly Bulletin, Mich. Agr. Exp. Sta., Vol. 35, No. 4, pp 454-459, May 1953.

The influence of orchard sods and clean cultivation upon soil moisture may be related to several factors. Age of sod, period of cultivation, type of soil, soil fertility, rainfall distribution, amount and intensity may be factors of primary importance. A study of soil moisture in relation to sod covers and clean cultivation was initiated at the Graham Horticultural Experiment Station near Grand Rapids, Michigan in 1950.

Procedure

A peach and a pear orchard were used in this study. The sod and clean cultivation practices had been established for 2 years in the peach orchard, and for 25 years in the pear orchard. Fescue sod was in the pear orchard, and a bluegrass sod in the pear orchard. Both orchards were on Miami silt loam. Soil moisture determinations were made with plaster of paris soil moisture blocks placed at 8-, 24-, and 42 inch depths.

Results

Rainfall was above average in July and below in August, September and October. Rainfall on all but three days (July 17, July 20, and August 25) totaled less than one-half inch. No rain exceeded 1.6 inches.

1. More available moisture was present in the plots receiving treatment for 2 years than those receiving treatment for 25 years.

2. Available soil moisture under the 2-year old sod was lower than in soil clean cultivated for 2 years, while under the 25-year old sod it was higher than in soil clean cultivated for 25 years.

3. The soil under the 25-year old sod contained more available moisture than did that under the 2-year old sod, but more was available under the soil clean cultivated for 2 years than under similar treatment for 25 years.

4. These differences in available soil moisture were observed at all depths.

5. Seasonal trends in available soil moisture show that there was a gradual decrease for all plots as the season progressed. Less than 60% of the available soil moisture was present under the 2-year old sod after August 14, under the soil clean cultivated for 25 years after August 7, and under the 25-year sod after September 11. More than 60% of the available soil moisture was always present in the plot clean cultivated for 2 years.

Summary

The observations indicate that sod covers when first established may deplete soil moisture more than clean cultivation. However, as the sod culture and clean cultivation programs are continued more soil moisture may be found under the sod than in soil clean cultivated. This reversal of relationships apparently results from the gradual depletion of the soil and loss of structure. The sod cover still uses a considerable amount of moisture, but has maintained or improved the soil in regard to rainfall penetration and moisture-holding capacity. Clean cultivation when first established eliminates any depletion of moisture by crop growth. However, continued clean cultivation may reduce rainfall penetration, increase runoff and reduce moisture-holding capacity of the soil. In these orchards, runoff was noticeable in the plot cultivated for 25 years, but was negligible on the other plots. Penetration was apparently reduced by long term cultivation, since the rains occurring after August 21 failed to have a marked influence on soil moisture.

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No. 5-53

September 22, 1953

SOIL AND WATER CONSERVATION - ILLINOIS

1952 Annual Progress Report for Urbana, Joliet, and Dixon Springs, Illinois.

Summary

1. Precipitation was below normal in the state in 1952 during the months of July through October. This definitely influenced soil and water losses and crop yields especially in central and southern Illinois.

Urbana

2. Plots planted to corn on the contour lose about one-half as much soil as compared to those farmed up and down the slope (12 year average). Soybeans planted on the contour lost only one-fourth as much as when farmed up and down the slope.

3. Soil losses from plots planted up and down hill to corn have been 23% greater than the same plots planted to soybeans (8 year average).

4. The soil loss for the month of June (1952) was greater than the average annual loss as recorded for a 12 year period.

5. Eighty eight to 95 percent of the total annual soil loss from corn and soybeans occur during the months of May, June and July while 60 to 81 percent of the total annual runoff occurs during this period.

6. An analysis of rainfall and soil loss records indicate a direct relationship between rainfall intensity and soil losses.

7. No tile flow was measured from the runoff plots during the period of April 1, 1952 to March 1, 1953.

8. Soil moisture studies indicate it is not unusual for corn to use up all of the vailable moisture to a depth of 4 feet. Summer rains normally do not moisten the soil beyond 12 to 18 inches from the surface.

9. The permeability of the plow layer was much greater where a standover legume occurred in the rotation than where corn and soybeans were grown without a standover legume. A high fertility program on a corn-soybean rotation did not greatly improve the permeability of the plow layer on Flanagan silt loam.

10. Fifty years of cropping to corn and soybeans did not seriously affect the permeability of the soil immediately below the plow layer on Flanagan silt loam.

Joliet

11. One storm in June with a rainfall intensity of 3.68 inches per hour for a 15-minute period produced practically all of the soil loss for the year.

12. Soil losses from 1st year corn were 1/3 less from plots where standover legumes occurred in the rotation as compared to plots where only a catch crop legume was used in the rotation.

13. Shallow, broad base terraces with a relatively steep channel (.5 ft fall/100 ft - 8 sq ft capacity) show definite promise for use by farmers on long gentle slopes. A close examination of the terraced area after one storm of high intensity (total 4.6") showed no overtopping or excessive scouring.

14. The corn yields and physical soil conditions on the mulch plots in 1952 were very encouraging. A great deal still needs to be done in perfecting methods of preparing a seedbed and cultivating the crops.

Dixon Springs

15. Soil losses from wheat have been more than two times greater on the 9% slopes and over 3 times larger on the 5% slopes than from similar plots in corn. Due to the longer period of time required to grow wheat and the higher rainfall months involved it assumes a critical position in the rotation. When soil loss from corn and wheat are based on a "per inch of rainfall" basis there is little difference in the rate of soil loss.

16. Soil loss, "per inch of rain" from corn was over three times greater where the crop residues were removed as compared to where they were returned (5% and 9% slope). On winter wheat soil losses "per inch of rain" was from 2.7 to 4.3 times greater where the crop residues were removed as compared to where they were returned.

17. All information obtained on the pasture runoff plots point to the value and importance of good soil treatment and regulated grazing. Good quality pasture during April and June is very important for satisfactory sheep gains.

18. Plots fully fertilized but intensively grazed contained twoice as many weeds as compared to the regulated grazed plots with the same soil treatment.

19. The 5 year average for runoff is somewhat less on the regulated, grazed plots as compared to the intensively grazed plots. However, the difference is not great.

20. On plots where grass was seeded in the fall without a companion crop and good moisture conditions prevailed, the grass was too dense to permit spring seeded legumes to become established. There appears to be very little difference in the composition of the sward five years after pasture plots were established by five different methods.